

R E P O R T R E S U M E S

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COMPUTER GRADING OF PHYSICS LABORATORY REPORTS.

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THE FEASIBILITY AND PRACTICABILITY OF USING A DIGITAL
COMPUTER (IBM 1620) TO GRADE PHYSICS LABORATORY REPORTS WAS
INVESTIGATED. IN ORDER TO TEST THE VALUE OF USING THE
COMPUTER, TWO TYPES OF COMPUTER PROGRAMS WERE WRITTEN FOR
EACH OF FOUR EXPERIMENTS. ONE PROGRAM COMPLETELY GRADED THE
REPORTS BY ENTERING THE STUDENT'S DATA AND HIS CALCULATED
RESULTS INTO THE MACHINE AND HAVING THE COMPUTER EVALUATE THE
CORRECTNESS. THE OTHER PROGRAM UTILIZED ONLY THE STUDENT'S
DATA. MAIN FEATURES OF THE PROGRAM WERE THE ANALYSES OF
SIGNIFICANT FIGURES, ARITHMETIC ERRORS, ACCURACY OF DATA, AND
TIME CONSUMED. THE INVESTIGATOR CONCLUDED THAT THE COMPUTER
GRADED THE REPORTS MORE EFFECTIVELY AND MORE QUICKLY THAN WAS
DONE PREVIOUSLY EVEN THOUGH THE COMPUTER WAS NOT PERFECT OR
EVEN COMPLETE IN GRADING. IT WAS THE OPINION OF THE
INVESTIGATOR THAT PLANS SHOULD BE MADE FOR FURTHER STUDY
LEADING ULTIMATELY TO THE INITIATION OF A COMPLETE
COMPUTER-GRADING PROGRAM FOR MOST ALL OF THE PHYSICS
EXPERIMENTS. (JC)

COMPUTER GRADING OF PHYSICS LABORATORY REPORTS

Cooperative Research Project No. 1641

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education

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1962

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PROBLEM

Each week during the regular academic session there are about 650 students performing sophomore (beginning) physic laboratory experiments at Auburn University. These students are divided among 25 to 30 sections with 20 to 26 students in each section. There are at most five, and at least three, different experiments performed simultaneously by separate sections of this group. Each student writes a report from the data taken in the laboratory and returns this within one week to his instructor for grading. The reports are hand graded, requiring a large expenditure of man hours each week. The time demanded for such operation of the laboratory necessitates that undergraduate upperclassmen and graduate students be used in a number of the laboratories. The use of inexperienced personnel together with the large numbers of students, results in low standards in performing the experiments as well as in writing the reports.

It is realized that the ever increasing enrollment will surely worsen the described situation, and steps are needed to correct it as effectively and promptly as possible.

The problem which is investigated in this report is to study the feasibility and practicability of using a digital computer (IBM 1620) to grade these reports. The results should point out the degree to which a computer might be used to its maximum effectiveness in grading laboratory reports while giving proper regard to the requirements made upon students.

OBJECT

The object of the report is to determine the degree to which a digital computer can be used in grading effectively sophomore physics laboratory reports.

RELATED RESEARCH

The authors found no information concerning a grading technique of this general type.

The students used as usual in the laboratory, and it preliminarily checked by the instructor, later prepared a report, and returned the completed report to the instructor within one week. From the reports on these four experiments, the investigator abstracted the necessary data and the related results of the student to enable him to prepare the computer program with pertinent IBM cards for total and partial gradings of the reports. For a fourth experiment the students were given the IBM cards in the laboratory, and these cards were filled out by the students. Cards which contained data taken in the laboratory studies were placed in at the end of the session, and cards which contained the results were placed in the reports which were collected the following week.

In order to test the value of using a computer to grade beginning physics laboratory reports, two types of computer programs were written for each of the four experiments. The program which grades the report by introducing the student's data and the calculated results into the machine and having the computer evaluate their correctness. The other program utilizes the student's data only. These data were programmed into the machine and the machine calculated the results.

The four experiments are:

- a. A study of Ohm's Law
- b. A study of the Wheatstone Bridge
- c. A study of the Potentiometer
- d. Gauss' method for measuring the earth's magnetic field

PROCEDURE

For three experiments performed during the summer quarter the students collected the data as usual in the laboratory, had it preliminarily checked by the instructor, later prepared a report, and returned the completed report to the instructor within one week. From the reports on these three experiments, the investigator abstracted the necessary data and the calculated results of the student to enable him to program the computer properly with pertinent IBM cards for total and partial gradings of the reports. For a fourth experiment the students were given the IBM cards in the laboratory, and these cards were filled out by the students.¹ Cards which contained data taken in the laboratory session were turned in at the end of the session, and cards which contained the results were placed in the reports which were collected the following week.

In order to test the value of using a computer to grade beginning physics laboratory reports, two types of computer programs were written for each of the four experiments. One program completely grades the report by introducing the student's data and his calculated results into the machine and having the computer evaluate their correctness. The other program utilizes the student's data only. These data were programmed into the

¹The four experiments are:

- a. A study of Ohm's Law
- b. A study of the Wheatstone Bridge
- c. A study of the Potentiometer
- d. Gauss' method for measuring the earth's magnetic field

computer and their accuracy was first evaluated by checking it for consistency. Then the required calculations were made by the computer and printed out to be used by the individual instructors when the reports were subsequently hand graded.

In using the computer for complete grading of the reports, the following procedure was employed:

The information used by the machine was obtained from the students' reports and was transferred to the IBM cards by the investigator. The cards were then punched automatically and fed into the machine. These cards came in two types which were specially designed for this purpose (see Appendices 1 and 2). One type, the data card, was required for inserting the data into the computer. The other type was the result card which furnished the computer the students' calculations, thereby providing the means for evaluation of their correctness. Summary data and result sheets were provided the student to expedite the subsequent card markings by the investigator (see Appendices 3 and 4).

The data cards contained sections for the student number, the card number and three pieces of data. Each datum consisted of its numerical value in the MKS system and in a special column the number of significant figures to which the datum was good. In a similar manner the result cards had sections for the student number, the card number, and two calculated results. Each result consisted of its numerical value in the MKS unit system, its number of significant figures, and its units. The units were coded and their numerical equivalent was recorded in the proper section.

Since all experiments were performed by pairs of students, only one

set of data cards was required for a pair of sets of result cards. In order for the machine to properly grade such a pair, the student numbers were assigned in such a way that the pair of result sets were processed with one data set. This was accomplished by assigning an odd number to the two students' data cards and the same odd number to one of the student's result cards. An even number was given to the other student where the even number was always three digits larger than the odd. The machine used the data with all result card sets that follow until an even student number was reached. After this set was graded, a new set of data was fed in and the process continued. The cards were sorted automatically so that little chance was left for error in such a procedure. The method was flexible since an additional result set could be graded with a single data set. Student numbers were assigned so that when an additional partner was temporarily assigned to the group, the situation was easily handled by enlarging to three the number of students using the same data. In this manner problems of students' absences, etc. could be effectively handled.

The handling technique for the completely graded report was developed as five individual operations: a check on the significant figures of the data, a check on the significant figures of the results, a check on the correctness of the calculations, a check on the units (MKS), a check on the accuracy of the data. The proper number of significant figures for a datum was determined by the scale of the instrument used and the size of the datum.²

²For example, a length measured by a meter stick would have two (2) significant figures if the length was less than 1.00 centimeter, would have three (3) significant figures if the length was between 1.00 centimeter and 10.00 centimeters, and would have four (4) significant figures between 10.00 centimeters and 100.00 centimeters.

The machine checked the significant figures of the students' data and compared them with the proper value. If the student was in error, five points was deducted. A maximum penalty was set for this evaluation after which the machine no longer penalized the student. The proper number of significant figures for the results was calculated by the machine using the numbers recorded by the student. In this manner the data and result significant figure checks were made independently. Again the machine penalized until a fixed number was reached. The calculation check used the numerical value of the data to calculate a particular result. The machine's and the student's results were compared and when they differed by a preset percentage, the student was penalized. Had later results depended upon this particular one, the student's value was used even though possibly in error. (In this manner each calculation check is kept independent.) For each calculation error, the student was penalized five points and no limit was set on the penalty assigned. The check on units was accomplished by coding the units and feeding the proper code numbers into the machine. Again no limit was placed on the maximum value of the penalty. In the check for accuracy, which consisted of the percent differences between correct values and those obtained by the students in the experiment, only the data was used by the machine. The accuracy required was decided upon for each experiment, and should the data not yield this accuracy, the student was penalized. No maximum deduction was set for this penalty. The output of this grading program was printed on rolls of paper and given to the individual instructors (see Appendix 5). This output consisted of the student number, the grade, and itemized penalties. It then printed the proper percent differences and the numerical value of the result with its units and significant

figures. This print-out was given to the student so that he could identify his errors.

The partial grading program used the check on the significant figure of the data and then made the desired calculations leading to the final results. It computed the correct value of each computation and the correct number of significant figures and printed the values out as before (see Appendix 6).

The effectiveness of these partially graded programs was checked against hand graded reports for the four experiments. A group of about fifty students was used as the test group. For three of the four experiments, the group turned in their reports as is usually done. The data and results were then transferred by the investigator to the data and result cards for use in the partially and completely graded computer programs. The reports were then given to two of the better undergraduate laboratory instructors for completion of their own grading. In this manner each experiment was graded three different ways: partially machine graded, completely machine graded, and completely hand graded. Standard penalties were set up for each error, and for this purpose no maximum total penalty for any one operation was set up for the machine. For these three experiments no machine check on units was made since the units would in effect be hand checked in all cases when the investigator transferred the data to the data cards. Listings of total number of errors for each type operation were then made and plotted on graphs. The time required for total machine, partial machine, and hand grading was recorded separately. Thus the effectiveness of each method was compared.

The fourth experiment, Gauss' method for determination of the earth's magnetic field, was handled differently in that the students filled in the

IBM cards themselves. The students used the summary data and result sheets which were provided (see Appendices 3 and 4).

The effect of having laboratory reports machine graded upon the student's work was investigated by making a before-and-after comparison of his grades.

In order to accomplish this, a total machine graded program was used on three experiments without the students' knowledge. The results of these reports were then given to the students before the fourth experiment was performed. The students' performance on the common features of the experiments (data significant figures, result significant figures, and arithmetic) was compared. This was accomplished by calculating the percent of each common feature which the student did incorrectly.

As a result the penalty for units from the machine was in seconds—practically negligible compared to the other penalties. As for the hand grading, either with or without machine penalties, the penalties pertaining to units was larger but still of about moderate significance.

The penalties resulting from the grading of the four (4) experiments are shown on graphs in Figure 2. This graph shows the penalties given by each method of grading for all four experiments along with a final graph showing the time required for each report.

The graphs for accuracy of data and arithmetic point out that the most severe penalties were incurred from the partial machine method of grading. This was due to the fact that the total machine method had a fixed number of check points, whereas the hand grader checks, at least ideally, every step. The penalties given for machine graded reports were considered quite severe (the last set of curves shows the machine checks the main results for each experiment in more detail). The graph for accuracy of data

ANALYSIS OF DATA

The main features of the program were the analyses of significant figures, arithmetic errors, accuracy of data, and time consumed. In considering the checking of units, however, it was felt that comparison of machine checking vs. hand checking of the units was meaningless. This opinion came from the fact that units were missed primarily because they were simply omitted from the results. In the machine grading procedure an empty space on the cards was provided as a reminder that units were necessary. As a result the penalty for units from the machine was in essence numerically negligible compared to the other penalties. As for the hand grading, either with or without machine results, the penalties pertaining to units was larger but again of minor numerical significance.

The penalties resulting from the grading of the four (4) experiments are shown on graphs in Figure 1. Each graph shows the penalties given by each method of grading for all four experiments along with a final graph showing the times required for each method.

The graphs for significant figures and arithmetic point out that the most severe penalties were received from the partial machine method of grading. This was due to the fact that the total machine method had a fixed number of check points, whereas the hand grader checks, at least ideally, every step. The resulting grades for machine graded reports were considered quite severe (too low) but they arise since the machine checks the main results for each experiment in some detail. The graph for accuracy of data

does not show the partial grading method since the grader used the penalty provided by the machine for each report.

It was noted that the time required to grade the reports using the partial grading method was the same as that required for completely hand grading (see Figure 1, graph 4). This is construed to mean that arithmetic was poorly checked in the hand grading.

Other items for which the students were penalized in hand grading were neatness, form of calculations, clearness of method, and organization of the reports. The total penalty for all of these was less than 150 points for the four experiments (approximately 200 reports). Since the value of these penalties was so small when compared to others, they were not graphed. Appendix 5 shows the penalties given in some detail.

The results of measuring the effect of the machine grading program on students' work is shown in Figure 2. Some qualifications should be mentioned in connection with the drastic improvement in significant figures as well as the smaller improvement of arithmetic. The experiments performed before the student knew that his work was being machine graded contained many data which were good to four significant figures. The students, in the main, recorded these data to three figures and were repeatedly penalized. This fact partially accounts for the large data significant figure improvement. The result significant figures on the other hand came from very similar type operations, consequently their comparison was considered quite significant. The arithmetic involved was many times more difficult in the latter experiment. It was decided that the few percentage points difference in the arithmetic comparison in reality represented a good improvement in the attention given to calculations.

CONCLUSIONS AND IMPLICATIONS

The conclusions reached by the investigator were based upon the explicit results of the report and the following contributing factors. One factor of importance was the nature of the hand grading procedure. The hand grading of the reports was performed by two of Auburn's better upperclassmen. These men have taught laboratories before and were experienced as teachers and graders. The quality of their grading was well above the average found in the sophomore program. This fact was noted before selecting them as graders for this project. It was decided that should the computer's overall results compare favorably with results of these men, one could draw meaningful conclusions.

In addition to the quality of the graders, one is careful to note that another factor was the lack of a large scale detailed planning for the methods of hand and partial machine grading. As a consequence the graders performed their tasks as they had in the past. The partial machine grading technique was at a disadvantage in that the grading procedure was the same as hand grading except that the results of numerical calculations by the machine were furnished the instructors for their convenience.

It was the investigator's opinion that the following questions should be answered before any conclusion should be drawn from the report:

1. Did the computer grade, in the main, the same aspects of a report that were considered essential to the proper evaluation of a report as practiced at Auburn?

2. Did the computer grade these aspects as well as was done previously?
3. Was the computer fair in its requirements of the students?
4. Did the computer grading have a beneficial effect upon the students?
5. Was an appreciable amount of time saved in using the computer technique?

Upon comparison of the completely computer graded reports with the hand graded reports (Figure 1) the answer to all the questions was found to be affirmative. The partially graded reports seemed to have been graded more completely and carefully. However, the large number of points deducted in the partial grading method was due to the multiple deductions by the instructor for errors which arose from previous erroneous calculations. Complete computer grading penalized the student only once for such errors. Furthermore, the time required for partially grading of the reports was much greater than that required for complete machine grading. This latter observation showed that the partially machine grading procedure appears overall inferior to the complete machine grading procedure.

The effect of machine grading upon subsequent students' efforts was considered to be a principal reason for using such a program. The improvement in the laboratory as judged by grades attained was considerable as viewed from the limited data. It appeared that the students would put forth the extra effort required for superior report writing if they knew that they would be penalized without exception for failure to do so. Realization of this fact alone greatly favors the use of a complete computer grading program of this general type.

Approximately one eighth of the time is required for total machine grading as for either of the other methods.³ Even larger time savings would

³The total machine grading time includes that for sorting and punching cards and processing.

result if larger numbers of students used the program. Should the number of students have been tripled, the hand grading would require 48 hours per week. The machine, on the other hand, could have processed this number in about three hours. Furthermore, if all sophomore reports for a given week in the academic year were hand graded, it would require 54 man hours. The computer could grade these same reports in about four hours. The saving of 50 man hours per week could be of enormous value to any university of comparable size.

The investigator concludes that the computer graded the reports more effectively and more quickly than was generally done previously. This is not construed to mean that the computer was perfect or even complete in its grading. However, from a practical point of view, use of the computer could be of real value in that it is relatively much superior to the usual hand grading method now being employed. It is the opinion of the investigator that immediate plans for further study should be made leading ultimately to the initiation of a complete computer grading program which would handle most, if not all, of the sophomore physics experiments.

FIGURE 1 COMPARISON OF GRADING METHODS

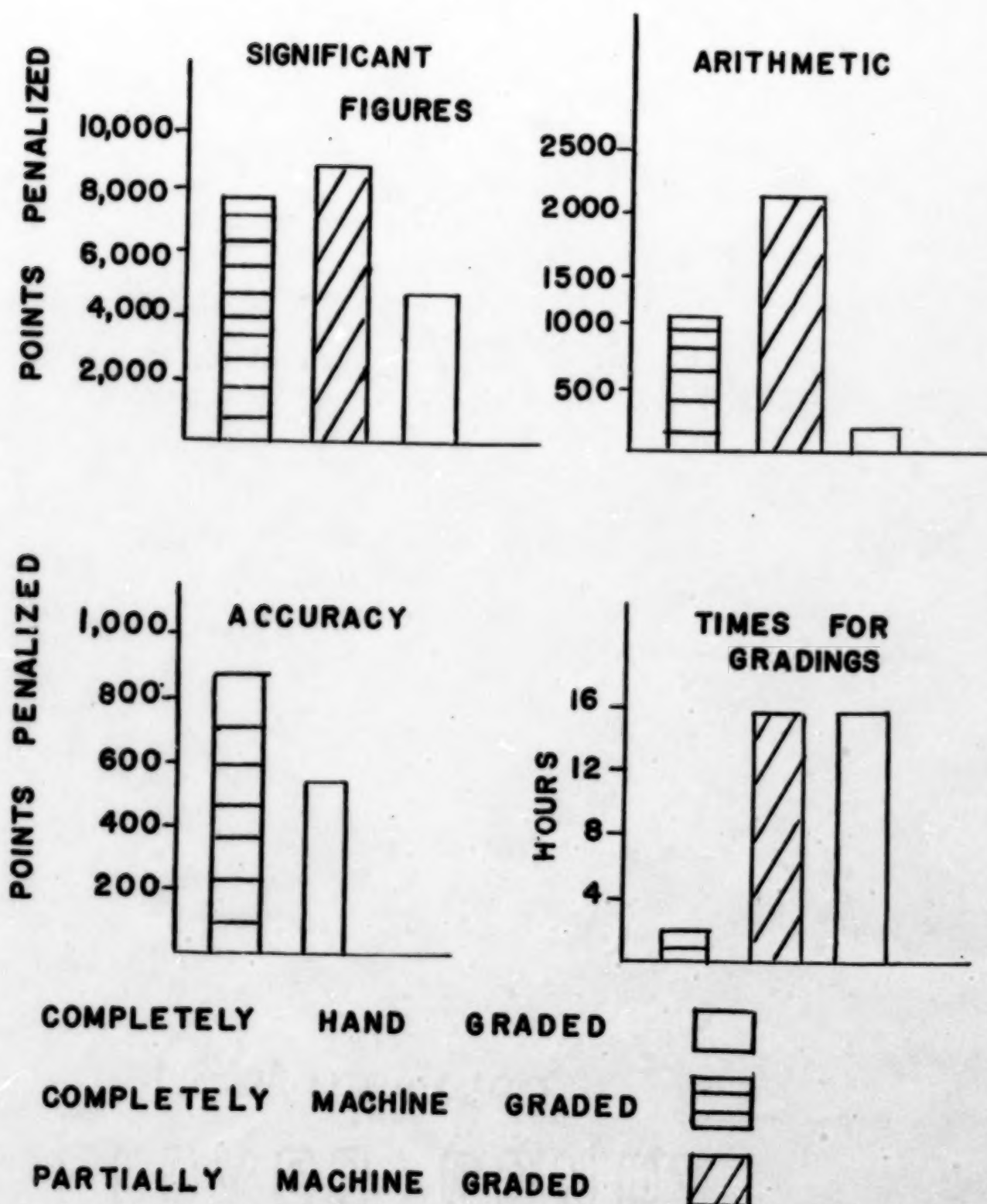


TABLE I

Total Penalties and Time for Each Procedure

	<u>Completely Machine Graded</u>	<u>Partially Machine Graded</u>	<u>Hand Graded</u>
Significant Figures	7955	8890	4880
Arithmetic	1220	2175	270
Accuracy	915		575
Time Consumed	2:20	16:00	16:00

FIGURE 2 EFFECT OF MACHINE GRADING ON PERFORMANCE

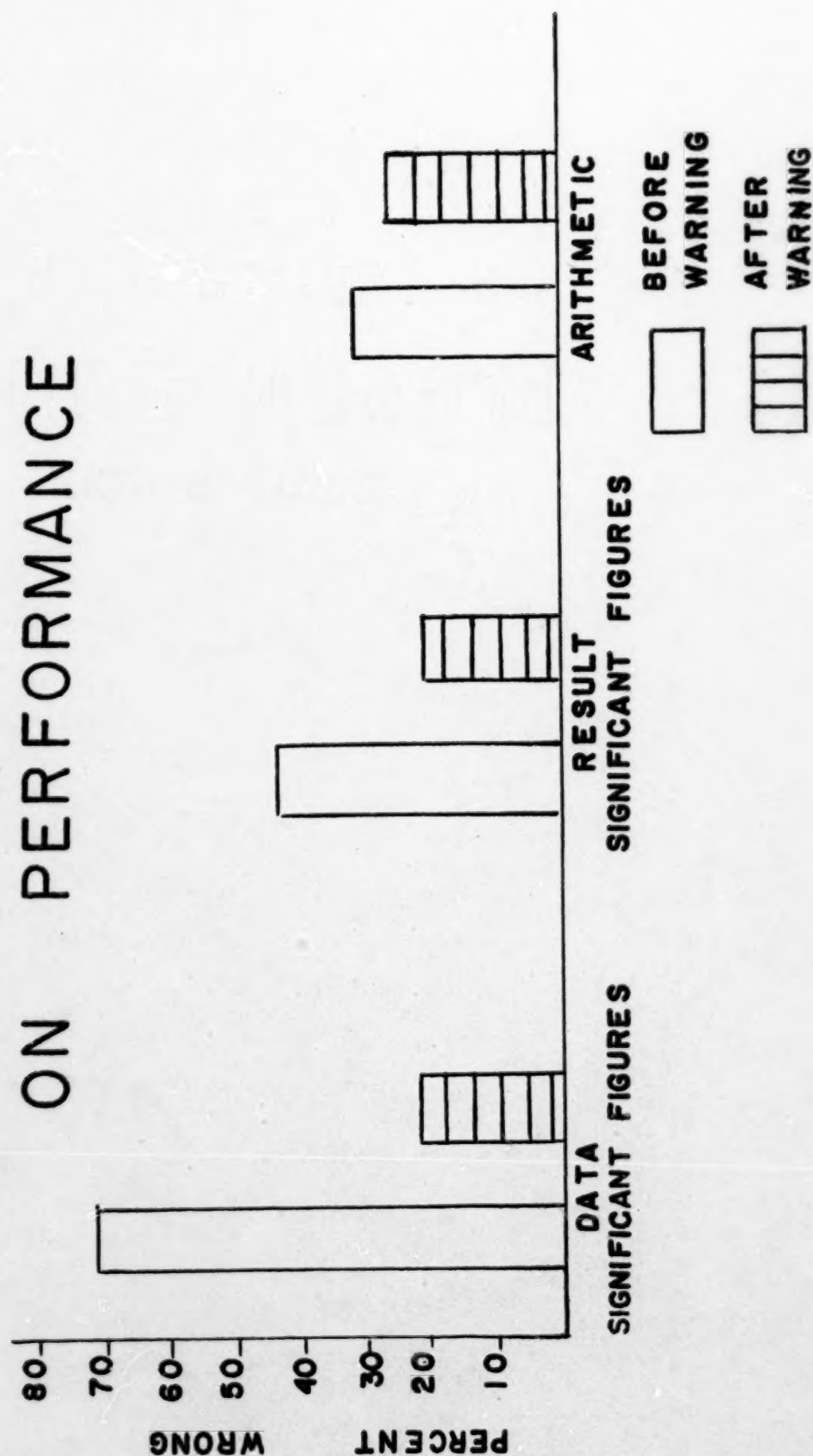


TABLE II

Itemized Penalties Given in Complete Grading Procedure

<u>Experiment</u>	<u>Data</u> <u>Significant Figures</u>	<u>Result</u> <u>Significant Figures</u>	<u>Arithmetic</u>
Ohm's Law	1230	705	360
Wheatstone Bridge	4215	550	310
Potentiometer	1435	255	395
Total	<u>6880</u>	<u>1550</u>	<u>1100</u>
Earth's Magnetic Field	335	340	395

Maximum Penalties Possible

<u>Experiment</u>	<u>Data</u> <u>Significant Figures</u>	<u>Result</u> <u>Significant Figures</u>	<u>Arithmetic</u>
Ohm's Law	3800	1710	1710
Wheatstone Bridge	3960	1080	1080
Potentiometer	1575	720	720
Earth's Magnetic Field	1680	1470	1470

Percent Wrong

	<u>Data</u> <u>Significant Figures</u>	<u>Result</u> <u>Significant Figures</u>	<u>Arithmetic</u>
Before Warning	72.8	44.1	31.4
After Warning	22.9	21.1	26.9

APPENDIX 2 SAMPLE RESULT CARD

1. Result Card No. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

2. Result 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

3. Sign for Power of Ten 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

4. Power of Ten 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

5. Units 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

6. No. of Sig. Fig. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

7. Students No. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

8. Date 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

9. Name 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

10. Signature 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

APENDIX 3

Summary Data Sheet (Use Pencil)

Use this as a summary of your data. Do not record data on this sheet other than indicated. Put all numbers in MKS units and in standard form.

		<u>Magnitude</u>		<u>Units</u>	<u>No. of Sig. Fig.</u>
	r	=	___.	x 10 meters	___
Data Card No. 1	Average θ	=	___.	x 10 degrees	___
	Width of Magnet	=	___.	x 10 meters	___
	Average time for 25 oscillations (inside)	=	___.	x 10 seconds	___
Data Card No. 2	Length of Magnet	=	___.	x 10 meters	___
	Mass of Magnet	=	___.	x 10 kg	___
	Average time for 25 oscillations (outside)	=	___.	x 10 seconds	___
Data Card No. 3	Dip Angle	=	___.	x 10 degrees	___

APENDIX 4

Result Sheet (Use Pencil)

		<u>Magnitude</u>	<u>Units</u>	<u>No. of Sig. Fig.</u>
Result Card No. 4	$M/B_h =$	____. x 10	____	____
	$I =$	____. x 10	____	____
	$MB_h =$	____. x 10	____	____
Result Card No. 5	$B_h =$	____. x 10	____	____
	$\frac{1}{B_h} =$	____. x 10	____	____
Result Card No. 6	$B_v =$	____. x 10	____	____
Result Card No. 7	$B_T =$	____. x 10	____	____

APPENDIX 5

SAMPLE OF PRINTED RESULTS FOR COMPLETE MACHINE GRADING

104 = STUDENT NUMBER GRADE = 60
DATA SF=-15 RESULT SF=-10 UNITS= 0 MATH =-15
DATA SIGNIFICANT FIGURES
R = 4 THETA =2 W =2 L =3
T = 3 M =4 TP = 3 DP ANGLE =2
MAGNITUDE SF UNIT MAGNITUDE SF UNIT
M/B= .132E-01 2 CUBIC M I = .699E-05 2 KG SQM
MB = .546E-11 3 SQW/M BH = .144E+08 3 W/SQM
BHP= .216E-04 3 W/SQM BV = .411E-04 2 W/SQM
B = .435E-04 2 W/SQM
ACCORDING TO YOUR DATA BH = .201E-04

APPENDIX 6

SAMPLE OF PRINTED RESULTS FOR PARTIAL MACHINE GRADING

104 = STUDENT NUMBER DATA SF = -15

DATA SIGNIFICANT FIGURES

R = 4 THETA = 2 W = 2 L = 3
T = 3 M = 4 TP = 3 DP ANGLE = 2

MAGNITUDE	SF	UNIT	MAGNITUDE	SF	UNIT
M/B = .132E-01	2	CUBIC M	I = .699E-05	2	KG SQM
MB = .542E-11	2	SQW/M	BH = .201E-04	2	W/SQM
BHP = .210E-04	2	W/SQM	BV = .421E-04	2	W/SQM
B = .619E-04	2	W/SQM			

APPENDIX 7

Penalties Given for Each Experiment

	<u>Data</u>	<u>Significant Figures</u>	<u>Result</u>	<u>Significant Figures</u>	<u>Arithmetic</u>	<u>Accuracy</u>
"Ohm's Law"						
Completely Machine Graded	1230		705		360	485
Partially Machine Graded	1230		965		665	485
Hand Graded	90		1300		65	210
"Wheatstone Bridge"						
Completely Machine Graded	2985		550		310	235
Partially Machine Graded	2985		925		535	235
Hand Graded	350		1120		75	255
"Potentiometer"						
Completely Machine Graded	1435		255		155	195
Partially Machine Graded	1435		335		225	195
Hand Graded	330		510		20	110
"Magnetic Field of Earth"						
Completely Machine Graded	385		340		395	--
Partially Machine Graded	385		630		750	--
Hand Graded	360		820		110	--

Project Description

#1641

"Computer Grading of Physics Laboratory Reports"

Howard E. Carr, Department of Physics, Auburn University,
Auburn, Alabama

May 1, 1962 to September 30, 1962

\$2,491.00

Objectives:

1. To evaluate the use of a computer for a partial grading program that will be useful in handling physics laboratory reports of large numbers of students.
2. To expand a partial grading program into a complete one and determine its effectiveness in grading laboratory reports.

Procedures:

A test group of laboratory reports from a single experiment for two laboratory sections in a third-quarter beginning physics course will be processed on an IBM 1620. The Format machine language will be used to grade reports. The two sections will have the same lecturer and section instructor as other sections of the course which will be graded conventionally. Comparisons will be made of the costs, time involved and the grades given by the two systems.